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SUMMARY OF PLANT EVALUATION CITY AND COUNTY OF DENVER'S
NORTHSIDE WASTEWATER TREATMENT FACILITY AUGUST-SEPTEMBER
1972

Environmental Protection Agency
Denver, Colorado

December 1972

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AUGUST SEPTEMBER 1972



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I. INTRODUCTION

The Denver Northside Wastewater Treatment facility is a large primary plant which serves the City and County of Denver as well as numerous industries and sanitary districts. The effluent from the Denver Northside plant is discharged to a large secondary facility (Metropolitan Denver Sewage Disposal District #1 - MDSDD #1).

As a portion of the Accomplishment Plan developed for the Metro Denver - South Platte River Basin by Region VIII of the U.S. Environmental Protection Agency (EPA), an evaluation was made of the Denver Northside Wastewater Treatment Plant. The purpose of this evaluation had many facets as would be expected with a plant of this size and complexity. Basically, however, the purpose of the evaluation was to determine through discussions with personnel involved with the plant, whether or not the facility was being operated and maintained satisfactorily to achieve the best protection for the waters of the South Platte River. This technical review was to then serve as a basis to determine what Regional resources, if any, could best be used to help Denver Northside with the various problems that they might be facing. The evaluation of the Northside plant led into areas including: industrial wastes, plant operations, administrative controls, sewer ordinances, relationship with MDSDD #1, and numerous others. These aspects of the evaluation are summarized in this report.

II. SCOPE

The evaluation of the Northside Wastewater Treatment Plant was achieved by interviews with staff personnel concerned with the operation of the Northside facility. Three or four visits were made to the plant by various EPA employees to discuss facets of the plant's operations, as well as collect pertinent data. A short meeting was held with MDSDD #1 personnel in conjunction with the Northside evaluation.

On site sampling by EPA personnel was not conducted during the evaluation of the Denver Northside Plant. All data collected and presented in this report were taken from plant records.

This report will outline in general the findings of the EPA evaluation of the Northside Plant. An attempt is made to discuss those areas where improvements or modifications could most beneficially affect the water quality of the South Platte River.

III. DESCRIPTION OF PLANT FACILITIES AND OPERATION

Figure 1 shows a schematic flow diagram of the Denver Northside Wastewater Treatment Facility. The major plant units consist of flow measuring devices (two large venturi meters), mechanically cleaned bar screens (5 units), grit removal facilities (5 channels), pre-aeration and grease flotation tanks (2 units), primary clarifiers

(8 units), and anaerobic digesters (8 units).

The various flow patterns within the plant for sewage, sludge, supernatant, grease, grit, screenings, and digester gas will be outlined.

A. Wastewater

Flow enters the plant through four main interceptor lines; the Delegany and Franklin Sanitary Sewer, the South and West Sanitary Sewer, the Broadway Relief Sanitary Sewer, and the Globeville Sanitary Sewer. Several problems exist with the Northside plant's collection system, such as existing combined sewers in the downtown area, limited capacity of the collection lines, and old age. The result of some of these problems is that frequently (two to three times a week) raw sewage (quantities are not known) is by-passed from the system directly to the South Platte River. Efforts are currently underway to alleviate the by-passing. Several new lift stations are being built, separation of storm and sanitary sewers is being practiced, etc.

Flow from three of the four main interceptors enters the plant by gravity. Flow from the Globeville interceptor is pumped from a wet well located on the plant site to raise it to the level of the inlet structure. A new lift station is being constructed on the plant site to pick up the flow from the recently constructed South Platte Interceptor No. 2. A portion of the flow in this new interceptor will be that raw sewage which is presently being by-passed from the automatic overflow on the South and West sanitary sewer.

Flow entering the plant is metered by two large venturi meters. Difficulties have been encountered with the venturi meters in keeping them cleaned and properly calibrated. This effort appears to require almost constant attention. Average daily flow entering the Northside plant for 1971 was 80.3 million gallons per day.

Two channels direct the influent to the screen-house where the flow is passed through mechanically cleaned bar screens with one inch openings. The two influent channels present a problem in sampling the combined flow entering the plant from the major interceptors. Presently a uniformly sized sample is collected from each channel hourly and composited. Samples are not composited proportional to flow.

After the sewage passes through the bar screens, it is directed to the grit chambers. The amount of flow dictates how many of the five grit removal channels are in operation at any one time, i.e. velocity in the grit removal channels is controlled by increasing or decreasing the number of channels in service as the flow increases or decreases.

The flow leaving the grit chambers is directed to two pre-aeration basins each followed by grease floatation and removal units. The effluent from the grease floatation units is split and directed to two sets of four primary clarifiers. The effluent from the eight primary clarifiers is recombined and transported through a 90 inch line to the MDSDD #1 plant to receive secondary treatment.

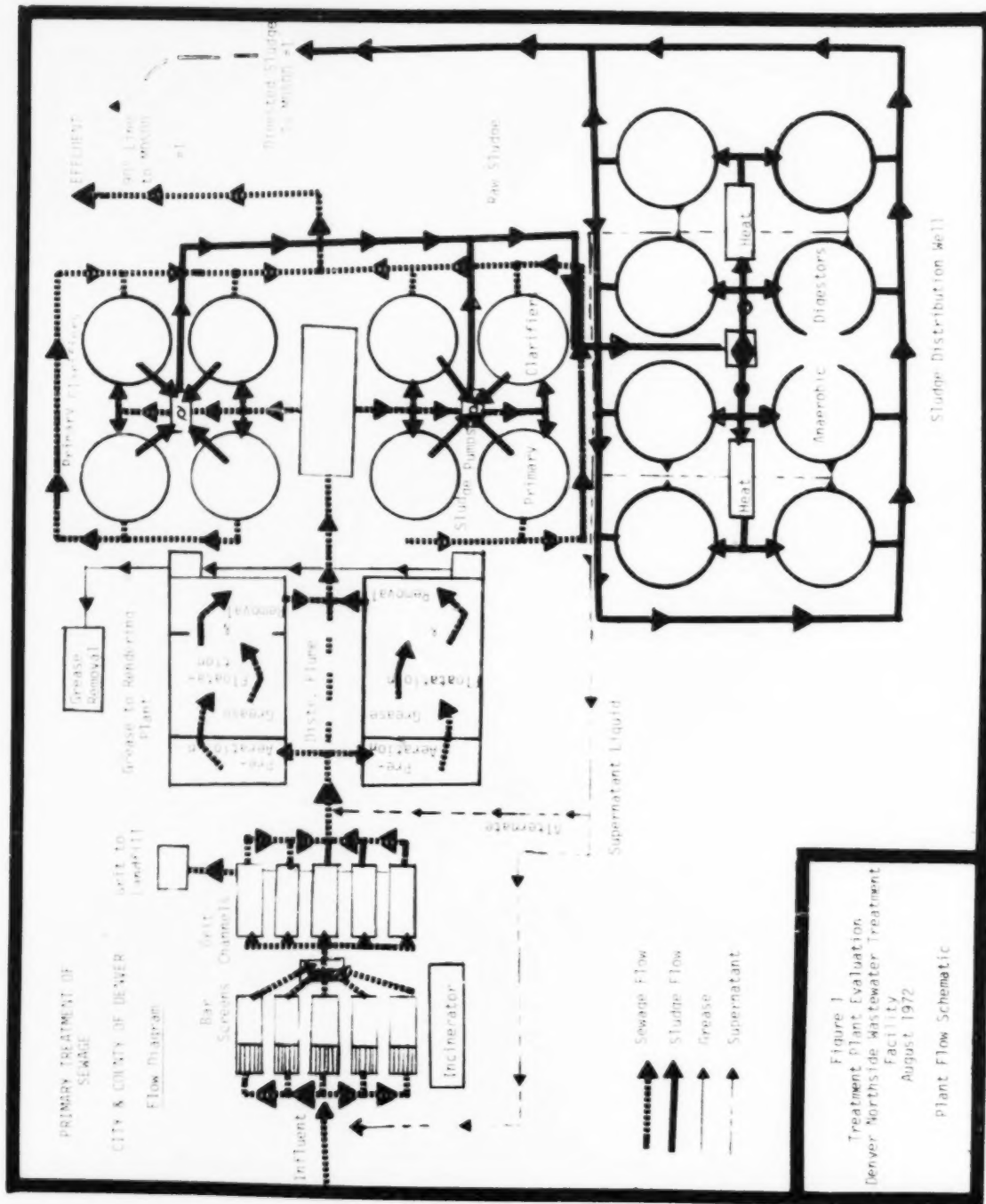


Figure 1
Treatment Plant Evaluation
Denver Northside Wastewater Treatment
Facility
August 1972
Plant Flow Schematic

Denver Northside is charged a service rate by MDSDD #1 which is determined from a formula which includes flow (45.51% of rate), BOD₅, (30.88% of rate), and suspended solids (23.61% of rate). The total amount Northside pays is adjusted annually according to the MDSDD #1 budget.

Another operational consideration that should be discussed is the present by-passing policy followed at the Northside plant. After heavy rains, peak flows will occur at the Northside plant. When these flows are at or near 130 million gallons per day, the quantity in excess of 130 MGD is by-passed manually to the river. The reasons given for by-passing at 130 MGD include the fact that the flights on the grease removal units become submerged and removal of grease is no longer effective, the primary clarifier weirs become submerged, the grease traps on the primary clarifiers become flooded and this flow is recirculated eventually back through the Globeville lift station to the influent compounding the flow problem, grit removal is less effective, the bar screens become clogged, etc. Although operationally the plant is by-passed at 130 MGD, the exact capacity of the facility is not known. Using an accepted overflow rate of 800 gpd/sf on the clarifiers, the mean capacity is calculated to be 106 MGD. A recent study by a consulting engineering firm working on expansion of the MDSDD #1 facilities concluded that hydraulically 160 MGD of flow could pass through the Denver Northside plant. MDSDD #1 flow records indicate that flows of this quantity have been received from the Northside plant.

B. Sludge

Sludge is settled in the eight primary clarifiers at the Denver Northside plant. This sludge is removed from the clarifiers by piston pumps in the two pumphouses which are centrally located between each set of four clarifiers. The sludge pumping cycles are controlled to attempt to draw a sludge with a high solids concentration. A low solids concentration in the primary sludge would increase the heating requirements in the anaerobic digesters as well as reduce the effective solids handling capacity. The solids concentration from the primary clarifiers is monitored by the use of a centrifuge and also by the operator's experience in recognizing a "thick" or "thin" sludge. Solids concentration from the primary clarifiers averaged 5.6 percent by weight in 1971. This is less than the 7 to 10 percent concentration of solids that MDSDD #1 removes in their primary sludge. It is possible that different influent characteristics or better clarifiers at MDSDD #1 could account for this difference. However, a significant increase in digester capacity can be realized from pumping a "thicker" sludge and any increase in the solids concentration from the primary clarifiers should be strived for.

Sludge removed from the primaries is pumped to a sludge distribution well located centrally between the eight anaerobic digesters. From this distribution well, the operator "feeds" the sludge to those digesters that are being used as primary digesters. Presently four of the eight digesters are being used as primary digesters, three are being used for secondary digesters, and one is out of service for modifications and repair.

Digested sludge from the secondary digesters is pumped twice a week (Tuesday and Thursday) by MDSDD #1 personnel to holding tanks on the MDSDD #1 plant site. The digested sludge is required to have a concentration of 5 percent solids by weight. The Northside plant is not charged directly for the removal of the digested sludge by MDSDD #1. The digested sludge from Northside is mixed in the MDSDD #1 holding tanks with raw sludge from Metro's primary clarifiers and with aerobically digested waste activated sludge from the MDSDD #1 secondary process.

C. Supernatant

Supernatant liquor is drawn off the secondary digesters at the Denver Northside facility and is presently being returned to the inlet structure ahead of the bar screens. (See Figure 1) It is noted that the supernatant liquor could be returned to the plant flow following the grit removal facilities. Several difficulties are encountered by returning the supernatant to the head of the plant. The major problem is that the supernatant is included in the influent sample, thus distorting the determination of the actual influent load from the collection system. Another major problem is the fact that the flow pattern of the supernatant through the plant is such that it only affects one half of the facility, thus theoretically overloading that portion of the plant. Some Denver Northside personnel feel that the supernatant should be returned to the head of the plant because it represents a load to the facility and therefore should be included in the determination of plant efficiency and also because they feel some removal benefit is gained by passing the supernatant through the grit removal facilities.

Supernatant removal from the secondary digesters is not a continuous process, but rather a draw and fill type process. Normally supernatant is drawn approximately four times a shift (12 times a day) from the secondary digesters. The obvious effect of this type of operation is the slug loading situation that it places on the other plant facilities.

Efforts to improve the quality of the digester sludge supernatant have been tried at the Denver Northside facility. The most recent investigation involved pumping the supernatant to an asphalted area which serves as a large shallow settling basin. The liquor from this basin is decanted from the top and the excess solids are left on the asphalt surface. At the time of the EPA evaluation, the asphalted area was full of solids and this practice of treating supernatant had been discontinued until the solids could be removed from the area.

D. Grease

Grease removed at Denver Northside is critical because no facilities are supplied at MDSDD #1 for removal of grease. Air flotation and skimming provide the first step in removing the grease at the Denver Northside plant. Skimmers are also provided on each of the eight primary clarifiers to aid in the removal of grease. Removal of grease was reported for 1971 as 5 tons per day for the air flotation units and 16 tons per day for the clarifiers. All grease that is removed is picked up by a local rendering plant for processing. Although grease removal appears

to be accomplished in a satisfactory manner at Denver Northside problems concerning grease have still been encountered at the MDSDD #1 facility. It may be that increased pre-treatment at the local packinghouses will be necessary to decrease any adverse effects presently being encountered with grease.

Settled solids are removed from the grease flotation and pre-aeration tanks by scrapers and returned mechanically by augers to the main distribution channel for the eight clarifiers.

E. Grit

Grit is mechanically removed from the grit channels, taken by an auger to a truck, and hauled daily to a landfill site operated on Lowery Air Base. The average quantity of grit for 1971 was 22 tons per day.

F. Screenings

Screenings larger than one inch in diameter are removed by the mechanically cleaned bar screens, and deposited on a pan where they are left to drain. They are then taken by a conveyor belt to a gas fired (digester gas) incinerator. The ash from the incinerator is removed and hauled with the grit to be buried daily. In 1971 an average of ten tons per day of screenings was fed to the incinerator.

G. Digester Gas

Gas produced by the primary and secondary digesters is used to mix the primary digesters by gas recirculation. It is also used as a fuel for heating the plant, the screenings incinerator, sludge heat exchangers, and other gas-fired equipment.

It is noted that Denver Northside presently has an EPA construction grant to provide modifications to its present anaerobic digesters. Each of the digesters will be provided with fixed covers and gas recirculation equipment as well as other modifications.

IV. SUMMARY OF EVALUATION

A. Plant Operations

The evaluation of the Northside plant indicated that the plant follows basically a sound operational program that should routinely provide adequate treatment. This mode of operation was arrived at, for the most part, by selecting the best methods based on operational experiences. Although operation was sound, it may be that detailed special studies into various aspects of the plant's operations will yield a more optimum performance from the facility. Suggestions for areas of study are outlined as follows:

1. Supernatant Liquor

The supernatant liquor represents that portion of the plant's operations that visually has the most significant effect on effluent quality. For this reason, improving the quality of supernatant liquor would be a good starting point in improving the plant's performance.

The most obvious method to decrease the effect of the supernatant liquor is to improve or optimize digester operations to produce the best quality supernatant. Although digester modifications are not yet completed, it may be possible to improve present operations by changing the ratio of primary digesters to secondary digesters, i.e., change from 4 primaries and 3 secondaries to 5 and 2, or 6 and 1, etc. Improved digestion may also be accomplished by increasing the concentration of solids removed from the primary clarifiers. An increase of one percent or even one-half of one percent in solids concentration can affect digester performance. Loading or "feeding" the digesters is another area that should be evaluated to determine the optimum loading rate. For example, it may prove more advantageous to load the primary digesters in smaller quantities at more frequent intervals.

Transfer of sludge to the secondaries should be evaluated to assure minimum disturbance of the contents within the secondary digester. It may also be beneficial to study ways of making drawoff from the secondary digesters a continuous or displacement type operation rather than the present draw and fill operation.

Each of the above outlined procedures will take time and laboratory support to investigate, but will insure that optimum operation has been achieved. When digester modifications are completed, further studies will have to be made to again determine the best mode of operation for the digesters.

When optimum digester operation has been established through controlled operational modifications, the best quality supernatant that can be achieved at the plant should be available for return to the plant flow scheme. It may, however, still be necessary to provide additional treatment for the supernatant to insure that its return to the flow scheme has a minimum effect on the plant's performance. Additional supernatant treatment could consist of the asphalted settling beds presently being used, chemical precipitation or polymer addition for better removal of suspended matter, or other methods of separate supernatant treatment.

A controlled program to minimize the effect of supernatant liquor on Northside's performance will provide not only an optimum level of treatment, but will also provide factual information to designers, planners, MDSDD #1, etc., as to the full capabilities of the Denver Northside plant.

2. Plant Sampling

Sampling is another area in which suggestions can be made to modify plant procedures. Although a change in sampling procedures will not modify plant performance, it is felt that the benefits derived from

obtaining factual information can be used in future design modifications to the Denver Northside plant, as well as in design considerations for the entire Metropolitan Denver wastewater treatment system.

Present sampling of plant influent is inadequate to describe the incoming waste load to the Northside plant. Sampling is not done proportional to incoming flow and supernatant liquor is included in the influent sample.

Proportional sampling throughout the plant would provide a much better insight into the actual loading to the facility. Proportional sampling should be tried and results compared with the normal way of sampling, i.e., compositing uniformly-sized grab samples.

Two approaches can be taken to eliminate the effect of the supernatant liquor on the influent samples. If the grit removal facilities aid in the treatment of the supernatant liquor as is claimed by plant personnel, then it is necessary that piping modifications be made so that a representative sample of plant influent can be collected. The other alternative is to return supernatant through present facilities to the point following the grit channels.

If the effect of supernatant on plant efficiency must be determined, then the supernatant waste stream must be sampled (composite proportional samples) and its waste characteristics analyzed. This determination of "in-plant load" could then be added with the incoming waste load to determine a total load to the plant. Using this approach, the overall reduction of incoming load plus in-plant load could be determined.

Whatever is done with the supernatant at Denver Northside, it is mandatory that the quality and quantity of the incoming wastewater be known. In fact, future modifications to wastewater treatment systems in the Metropolitan Denver area may require an even more complete characterization of the incoming waste to Northside in order to adequately design treatment facilities. For example, if water reuse becomes a reality then tertiary or advanced waste treatment methods will become necessary. Parameters such as nitrogen, phosphorus, heavy metals, etc., will become important. Background information or rather baseline data in these areas should be gathered now, prior to the design of such facilities. The size and importance of the Northside plant in the overall treatment of wastes in the Metro area make it mandatory for this facility to collect representative samples to provide data for future designs and modifications.

3. Miscellaneous Operations

Many areas at the Denver Northside plant appeared to be adequate. The laboratory appears to be well equipped and capable of producing reliable data. Although the laboratory personnel estimated that seventy percent of its work was done for the treatment plant (the other work is done in the Industrial Waste program), there seemed to be little flexibility or time to do specialized testing to improve plant operations. The importance of flexible laboratory support to aid in optimization of plant performance cannot be overstated.

The maintenance program and preventative maintenance program at the Denver Northside facility is very good. Records and schedules are kept on all pieces of equipment and back up supplies are provided wherever it is economically feasible. An alternate power source is being developed.

The Industrial Waste program has done a commendable job in reducing the strength of waste discharges from the various "customers" to the Northside system. This has alleviated much of the load on the Denver Northside facility as well as the MDSDD #1 plant. The only comment necessary concerning this program is that there must be an awareness of the types and strength of waste that affect not only a primary facility, but a secondary facility as well. Efforts should be made to eliminate all quantities or sources of wastes that could affect a secondary plant despite the fact that they may have little effect on a primary facility.

The efforts of the City and County of Denver to improve their collection system must also be mentioned. The separation of combined sewers, the use of T.V. cameras and sealing equipment, mechanical tapping, reduction of flow from industries, etc., have all aided in improving flow control in the Northside system.

Flow measurement at the Northside plant has continually provided problems. It appears that continuous cleaning, maintenance, and adjustment will be necessary to maintain reliable flow readings.

B. Other Areas of Evaluation

One of the most difficult problems that Denver Northside faces as well as people or organizations dealing with Northside is trying to establish the facilities capacity. Since the capacity of Northside directly affects expansions at MDSDD #1, it is imperative that Northside capacity be established. Northside admittedly by-passes manually to the river at approximately 130 MGD. This is far below the 160 MGD capacity that was reported in a recent predesign study done for MDSDD #1.

The lack of information on Denver Northside's capacity points to another difficult problem which is one of separate planning, design, and expansion activities of the Northside and MDSDD #1 facilities. This is apparently true not only for Northside and MDSDD #1, but also for the other facilities in the Metropolitan Denver area. Despite the available mechanisms for area wide planning, the job of coordinating wastewater treatment plant development to affect an interrelated system capable of economically accomplishing the water quality goals is not being done.

This is evidenced by the lack of coordination between expansion efforts between the two largest facilities in the area, Denver Northside and MDSDD #1. Apparently the recent predesign study done on the MDSDD #1 did not consider the possible use of the expanded digester capacity that may be available at the Northside plant when digester modifications are completed. An analysis was made of the potential capacity of the Denver Northside digesters using current design parameters available

in the literature. A portion of this analysis is shown in Table 1. Although different assumptions (i.e., more secondary digesters and less primary digesters or use of all eight digesters, etc.) would yield different results, the table shows that at design flow of 106 MGD at Northside, the digesters could still take a minimum of 26,000 lbs. of solids per day to a possible maximum of 113,200 lbs. of solids per day from the MDSDD #1 plant. This analysis assumes that the digester modifications underway at Denver Northside are complete (i.e. gas recirculation, cleaning, etc.).

Many other facets of the two plants should be studied jointly in a system approach, rather than an individual plant approach. This situation must be resolved and future efforts must include an evaluation of the two plants as a system if the best possible treatment is to be economically achieved.

V. CONCLUSIONS

The Denver Northside plant follows a basically sound operational program that should routinely provide adequate treatment. However, many areas of the plant have not been studied in sufficient detail to assure that the optimum performance is being obtained. Specific areas which need special studies to achieve optimum treatment are digester operations and handling of supernatant liquor. Other areas that might also benefit from special studies are plant sampling procedures, sludge drawoff from primary clarifiers, chemical or polymer precipitation studies, etc. Emphasis on these types of special studies as well as laboratory support for these studies was not available at the Northside plant.

Many areas at the Denver Northside plant and in the Northside system were adequate. The laboratory was generally well equipped and was apparently providing reliable data. The preventative maintenance program was good and appeared to be adequate to handle most situations that may occur or indeed prevent many breakdowns from occurring. The Industrial Waste program has aided in reducing the quantity of waste discharged by the various industrial contributors to the Northside system. The City and County of Denver has initiated effective programs to control the flow discharged to the collection system.

Because Northside is a prominent portion of the wastewater treatment system in the Metropolitan Denver area, it must assume responsibility for completely characterizing its wastewater to aid in future design and modifications to the Metropolitan Denver wastewater treatment system.

The capacity of the Denver Northside plant is not exactly known. This makes future predications concerning use of the plant difficult to determine. Presently by-passing is done by Northside personnel when the flow is approximately 130 MGD. The flow in excess of 130 MGD must be adequately treated in the future.

Present planning for expansions or modifications to the Denver Northside and MDSDD #1 do not appear to be coordinated to obtain the most satisfactory and economical treatment of wastewater. This situation must be altered so that future modifications can be determined on a

TABLE 1
TREATMENT PLANT EVALUATION
DENVER NORTHSIDE WASTEWATER TREATMENT FACILITY
AUGUST 1972

"EVALUATION OF DENVER NORTHSIDE DIGESTER CAPACITY"

Daily Average Plant Flow <u>1</u>	DNS Suspended Solids Concentration To Digesters <u>2</u>	Proposed Total Flow To Digesters <u>3</u>	DNS Flow To Digesters <u>4</u>	Possible MDSDD #1 Flow To Digesters	Assume MDSDD #1 Suspended Solids Concentration To Digesters	Possible MDSDD #1 load To Digesters
MGD	MG/L	MGD	MGD	MGD	MG/L	Lb/Day
80.3	56,000	0.390	0.22	0.170	40,000	56,600
80.3	56,000	0.390	0.22	0.170	60,000	85,000
80.3	56,000	0.390	0.22	0.170	80,000	113,200
80.3	80,000	0.390	0.154	0.236	40,000	78,600
80.3	80,000	0.390	0.154	0.236	60,000	118,000
80.3	80,000	0.390	0.154	0.236	80,000	157,200
106.0	56,000	0.390	0.312	0.078	40,000	26,000
106.0	56,000	0.390	0.312	0.078	60,000	39,000
106.0	56,000	0.390	0.312	0.078	80,000	52,000
106.0	80,000	0.390	0.22	0.170	40,000	56,600
106.0	80,000	0.390	0.22	0.170	60,000	85,000
106.0	80,000	0.390	0.22	0.170	80,000	113,200

1. 80.3 MGD = 1971 Average Daily Flow to DNS
106.0 MGD = Assumed Maximum Average Daily Flow at DNS
2. 56,000 MG/L = 1971 Average Suspended Solids Concentration Pumped to Digesters (Denver Northside Data)
80,000 MG/L = Assumed Concentration Pumped to Digesters - Maybe Possible With Improved Operation
3. Total Flow Based on 5 Primary Digesters (781,000 Ft.³ Capacity) and 15 Days Detention Time in Primary Digesters (D.T. In Secondary Digesters = 6 Days).
4. 0.22 MGD = 1971 Average Flow to Digesters (Denver Northside Data)
0.154 MGD = 0.22 MGD X 56,000 MG/L (i.e., Same Number of Pounds of Sludge Pumped 80,000 MG/L To Digester as in 1971, But At a Thicker Concentration)
0.312 MGD = Flow to Digesters With 106.0 MGD Influent Flow; 254 mg/l Influent Suspended Solids Concentration; 65% S.S. Removal; and 56,000 mg/l S.S. Sludge Concentration
0.22 MGD = Same as 0.312 MGD Except With 80,000 MG/L S.S. Sludge Concentration

NOTE: The following assumptions were made:

1. 5 Digesters Used as Primaries and 2 Digesters Used as Secondaries
2. Detention Time in Primary Digesters = 15 Days
3. 1 of the 8 DNS Digesters Will Always Be Down For Repair
4. Primary Digesters Will Be Continuously Fed, Completely Mixed With Gas Recirculation
5. DNS Average Influent Suspended Solids Concentration Will Be The Same At 106.0 MGD As At 80.3 MGD (i.e., 254 MG/L)
6. At 106.0 MGD, DNS will remove 65% Of The Suspended Solids Load

complete system approach rather than a separate plant approach.

VI. RECOMMENDATIONS

The results of the evaluation of the Denver Northside Wastewater treatment plant led to the following recommendations:

1. An intergrated approach to the design and development of the entire Northside - MDSDD #1 system must be taken to assure the most satisfactory and economical treatment of wastewater. This should include modifications presently underway.
2. Areas of the plant's operations must be studied in detail to ascertain that the optimum performance is being obtained from each portion of the facility. A few areas suggested for this type of study include: digester operation, primary clarifier sludge drawoff, handling of supernatant liquor, plant sampling, influent waste characterization, flow measurement, and by-passing practices.
3. The exact capacity of the Denver Northside facility for all portions of the plant (i.e., digesters, clarifiers, grease removal units, etc.) must be determined.
4. Sampling at the Denver Northside facility must be modified to assure that baseline data on influent and effluent flow is obtained for future design requirements. This must include parameters that may be needed to adequately design advanced waste treatment systems necessary for water reuse.
5. Coordination between the separate management groups of the Denver Northside and MDSDD #1 must continue to improve.
6. Efforts to eliminate all by-passing from the Denver Northside collection system must continue.